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(71) Applicant
Danfoss A/S

(Incorporated in Denmark)

6430 Nordborg, Denmark

(72) Inventors
Svend Peder Pedersen
Volker Spies

(74) Agent and/or Address for Service
Abel & Imray
Northumberland House, 303-306 High Holborn,
London, WC1V 7LH, United Kingdom

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F16K 31/70

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None

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UK CL (Edition J) F2V VP30 VS25 VS43
INT CL⁴ F16K, G05D

(54) Temperature-responsive valves

(57) A temperature-responsive valve has a housing (1) in which there is mounted a temperature responsive first helical spring 17 or metal actuating element (17*a*) for moving a valve closure member (9, 9*b*) so as to close and open the valve, the spring or element preferably having a shape memory, and a temperature-insensitive second helical spring (20) which acts against the closing force of the first helical spring (17) or element (17*a*). The valve closure member (9) includes apertures (13) connecting the interior of the first helical spring (17) with an annular chamber (21) within the second helical spring (20) and radially beyond the valve seat (8). Adjustment can be effected by rotating screw-theaded ring (5), and a number of alternative valves, some with different adjustment features are disclosed.

Fig.1

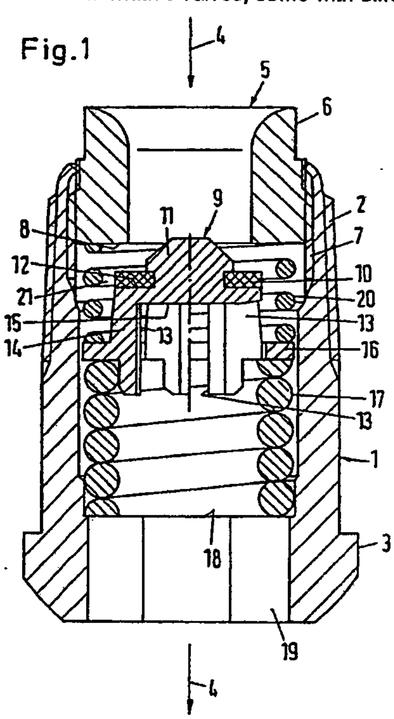

Fig.33

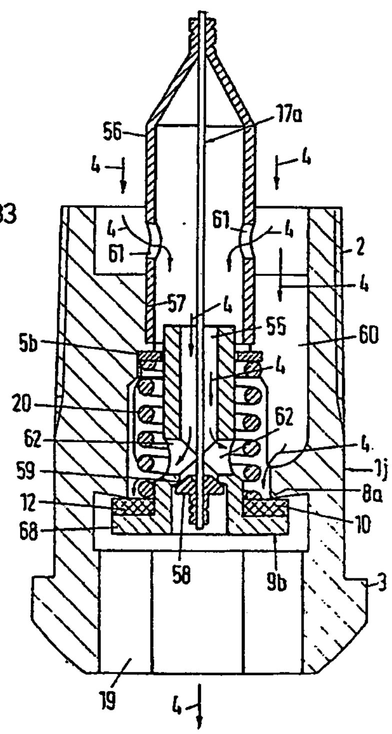

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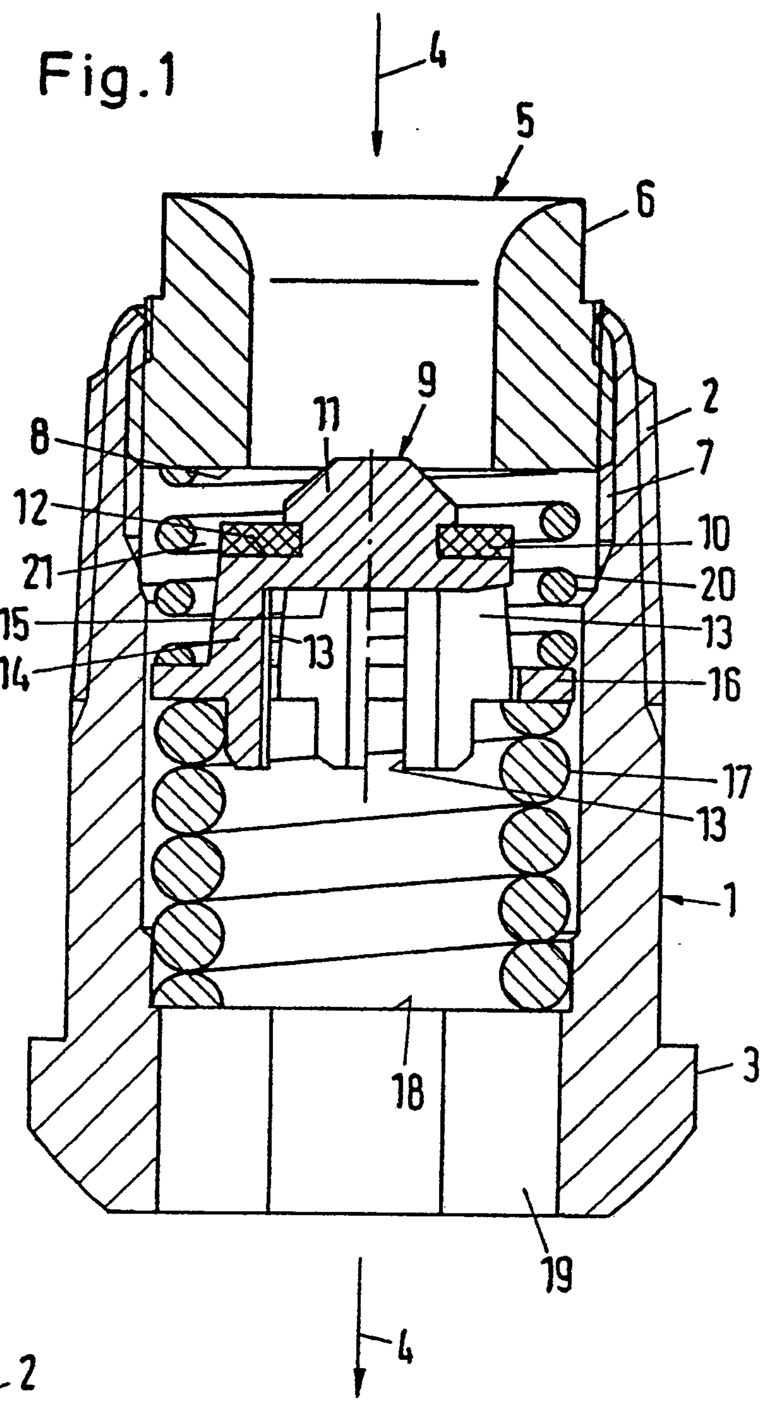
Fig. 1



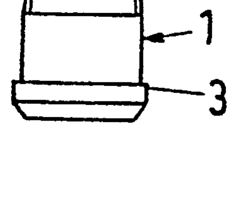


Fig. 2

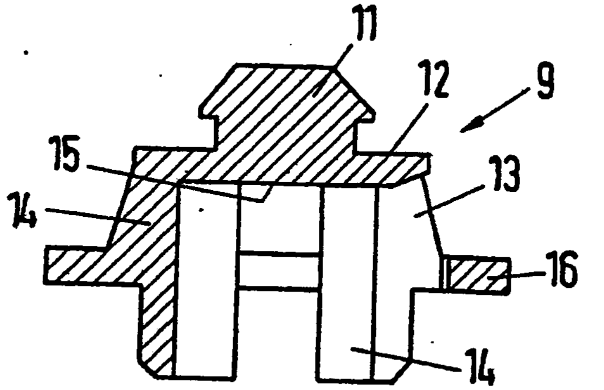


Fig. 5

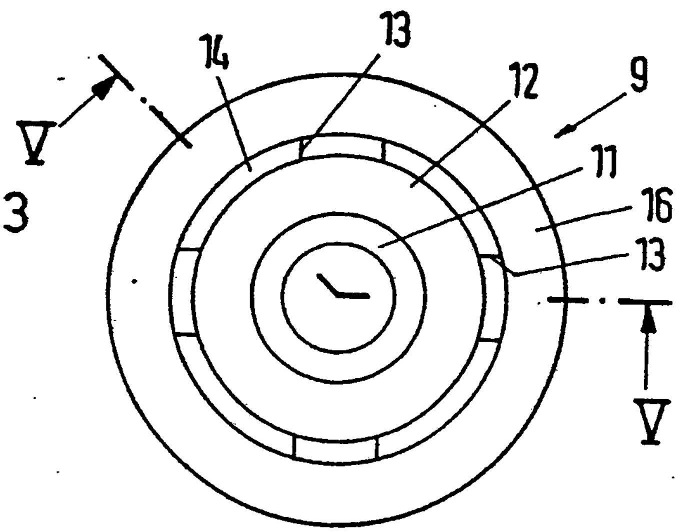


Fig. 3

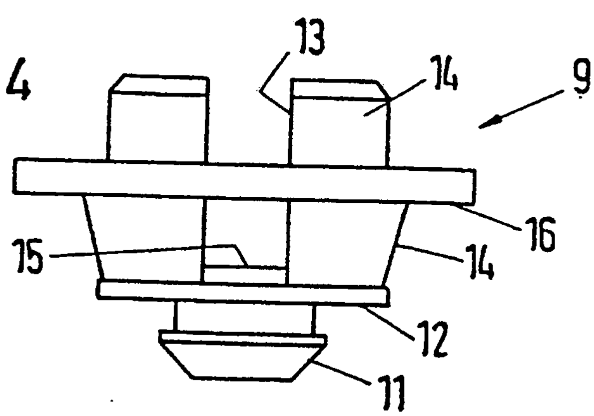


Fig. 4

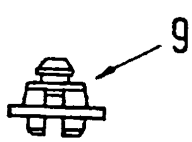
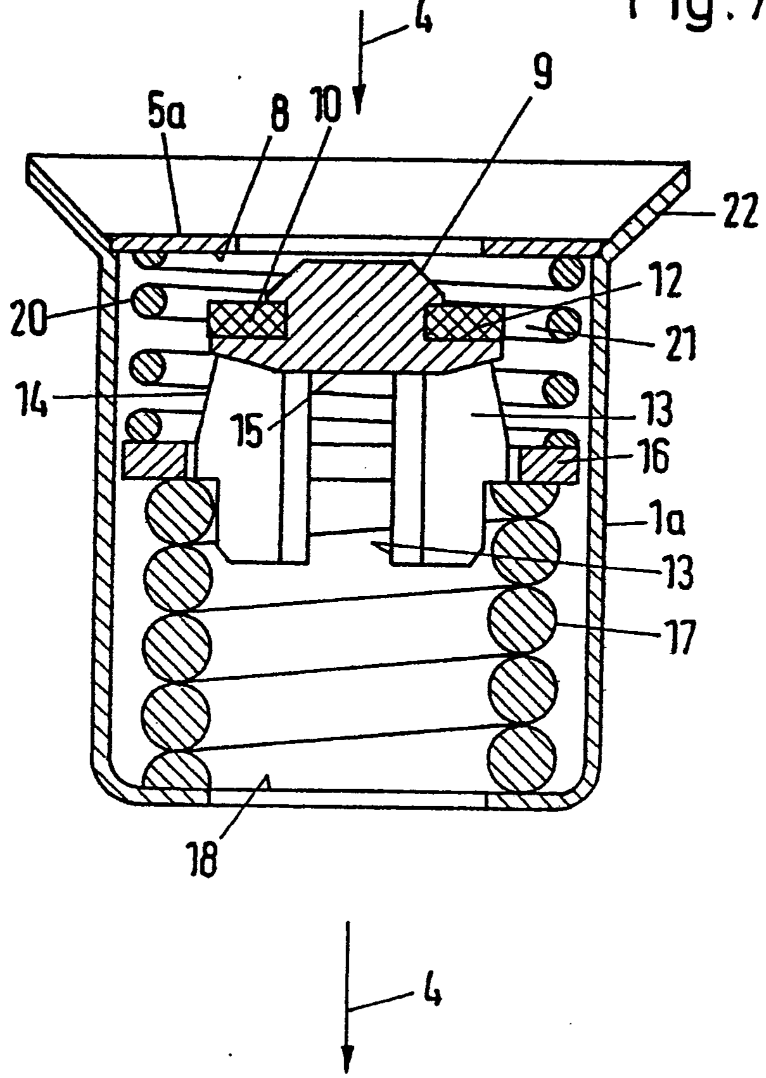


Fig. 6

Fig.7



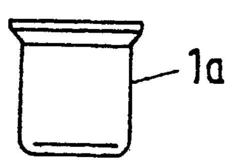
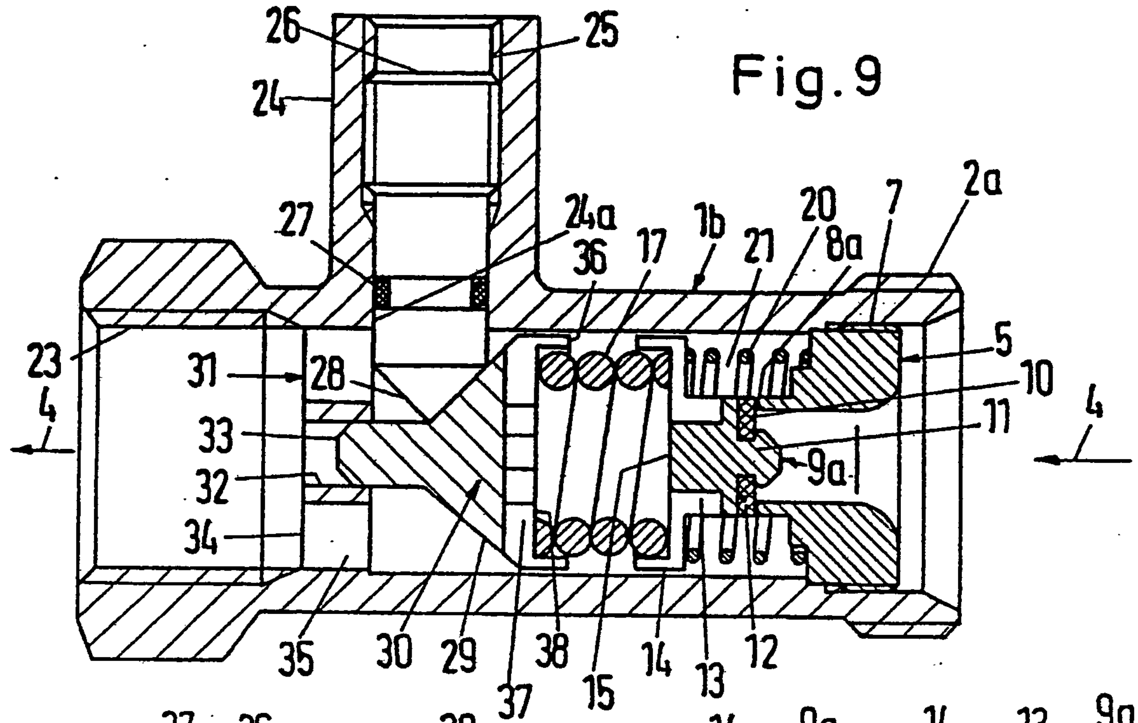


Fig.8



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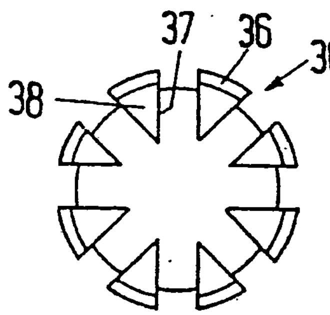


Fig. 10

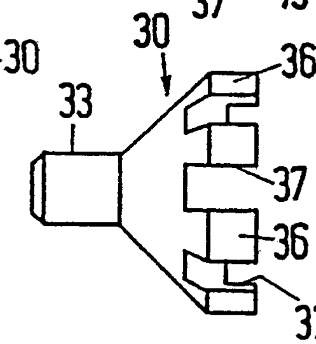


Fig. 11

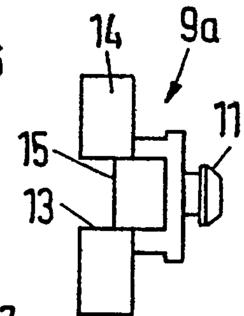


Fig. 12

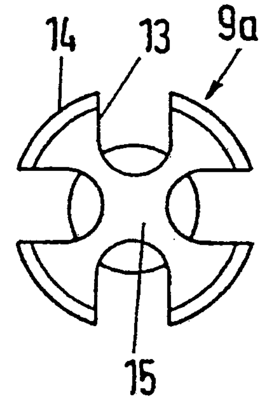


Fig. 13

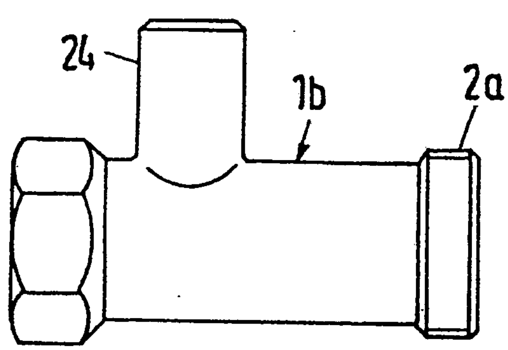
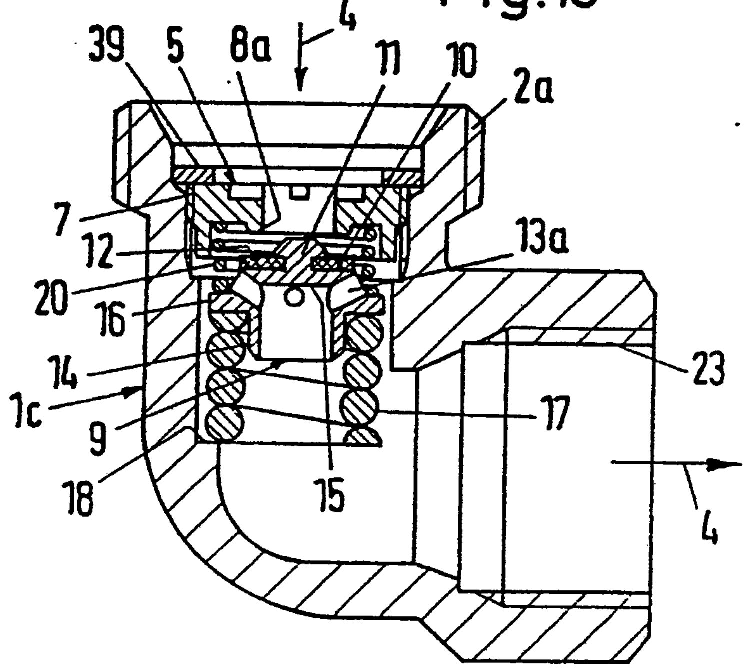


Fig. 14

Fig.15



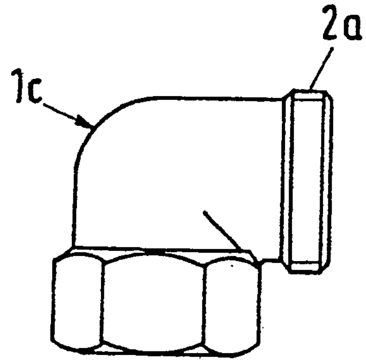


Fig.16

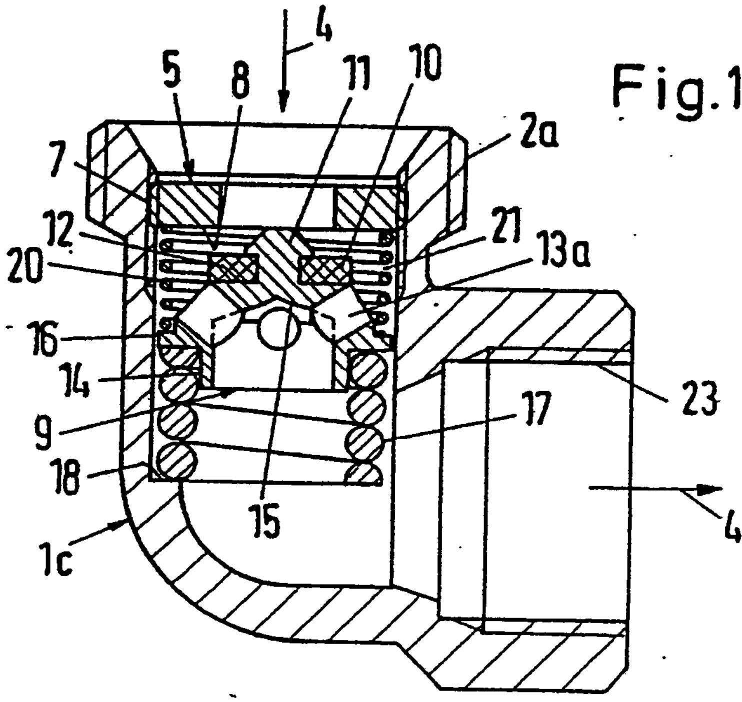


Fig.17

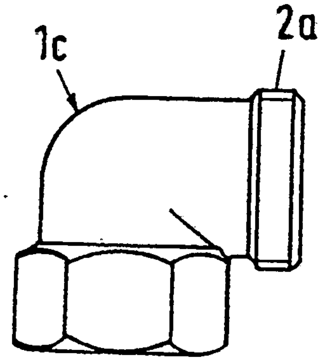
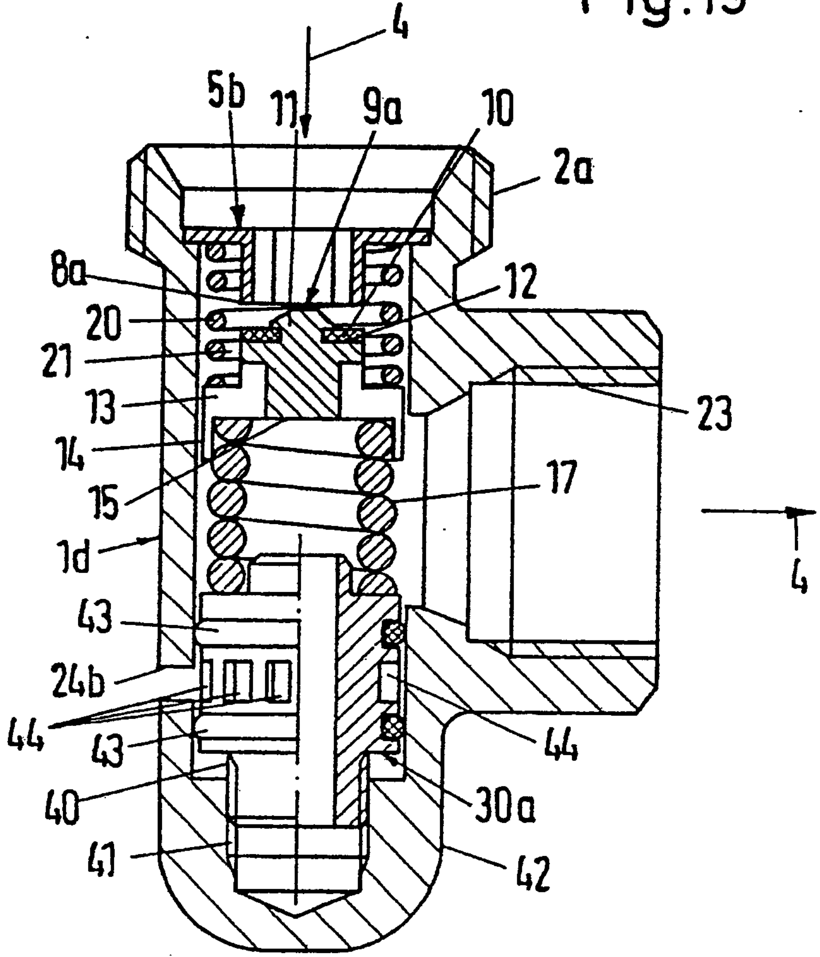


Fig.18

Fig.19



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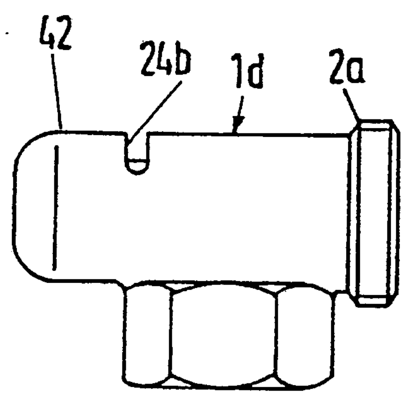

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Fig.20

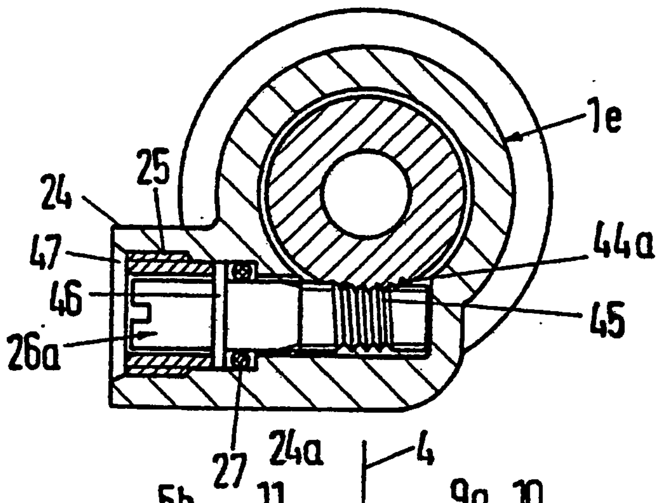


Fig. 22

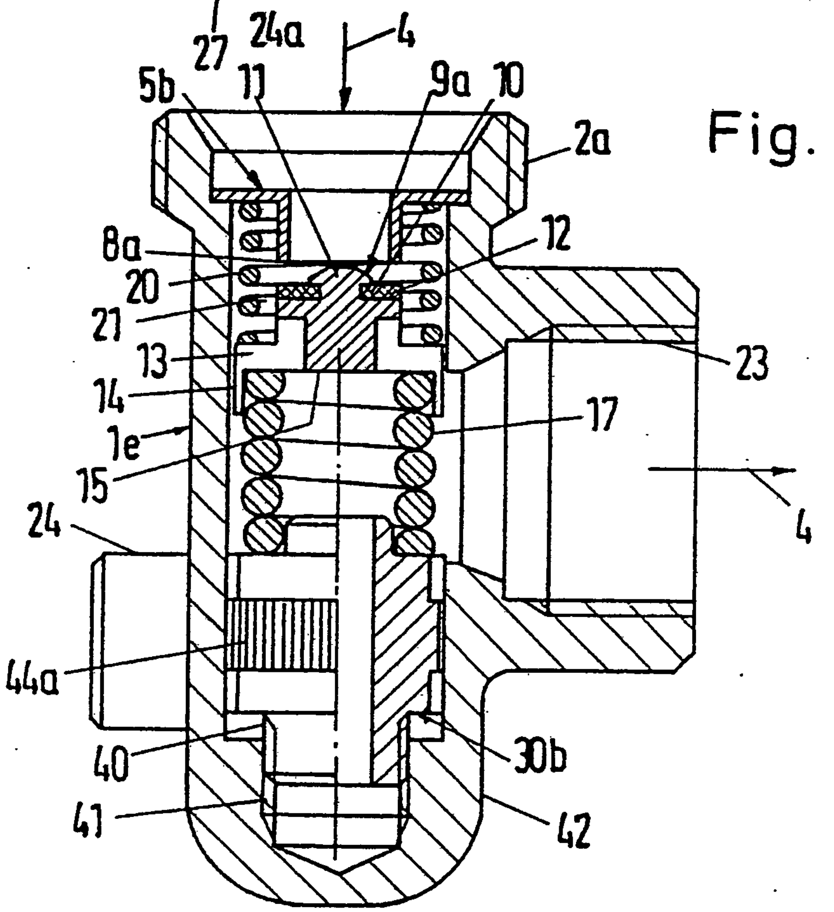
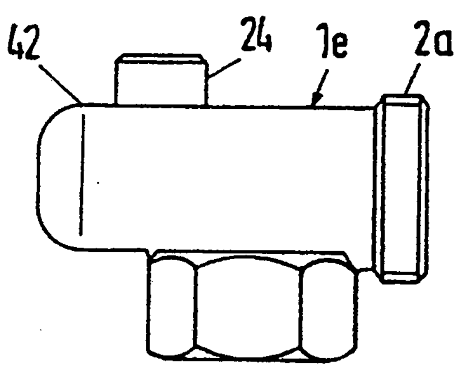


Fig. 21



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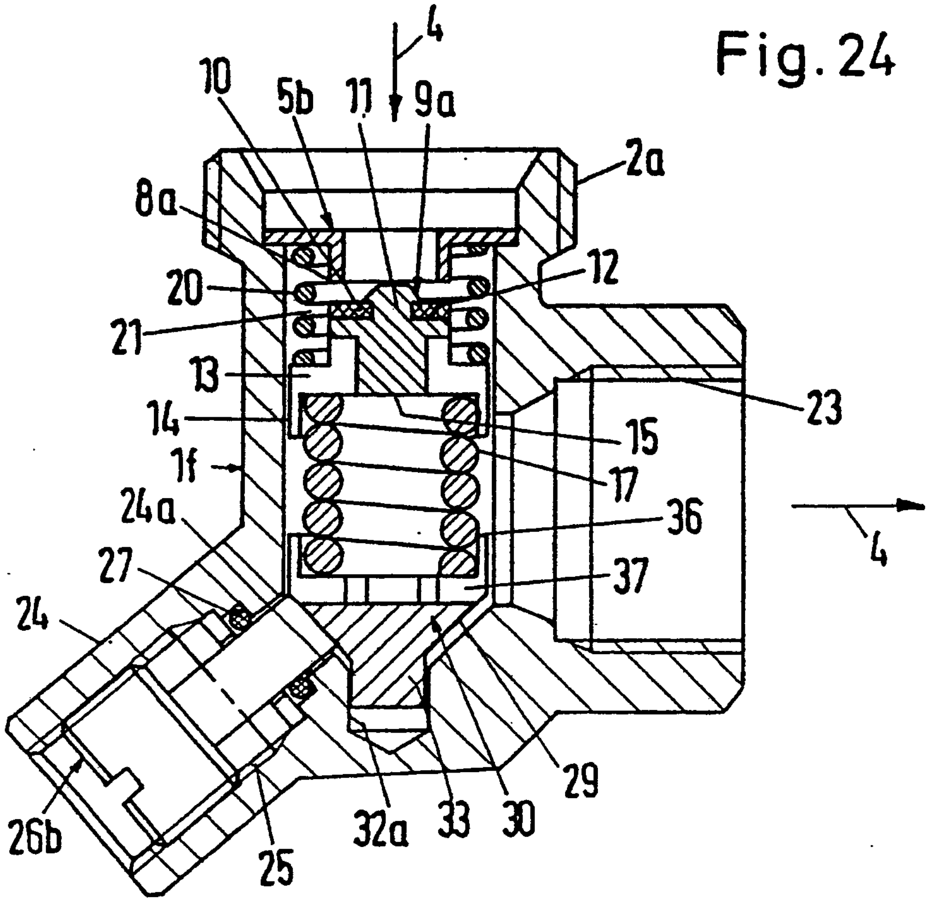
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Fig. 24

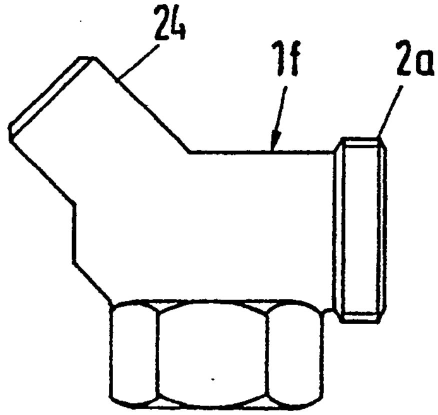
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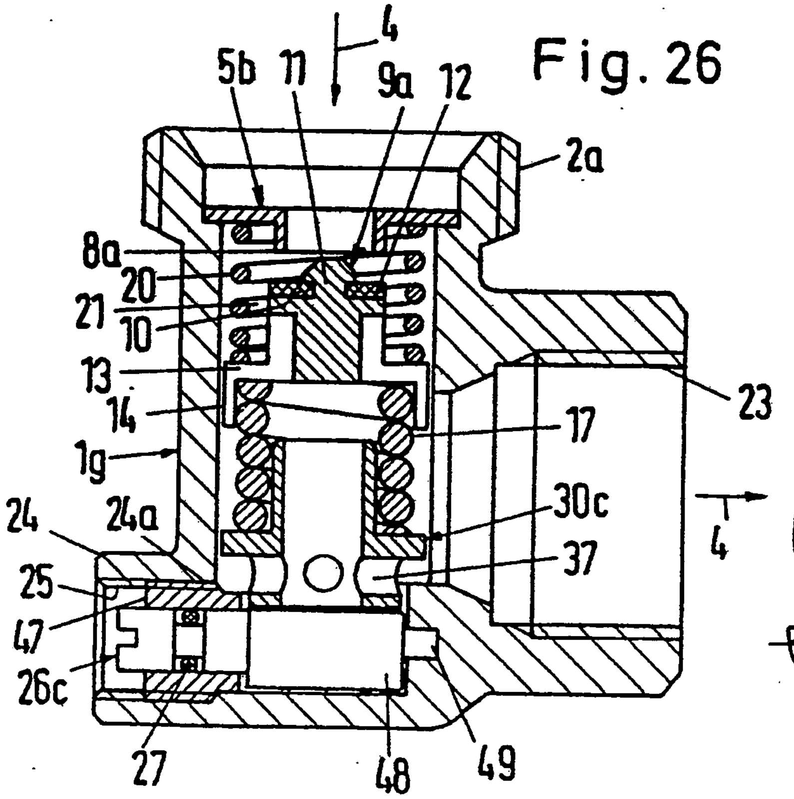
Fig. 25

Fig. 26



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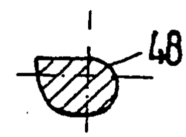

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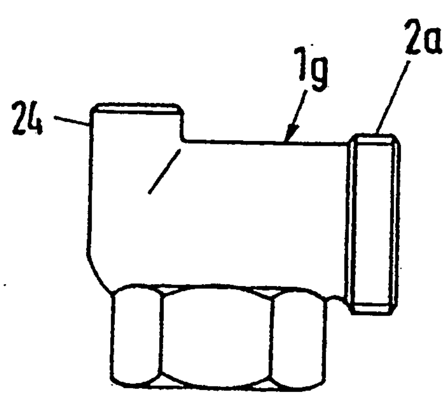

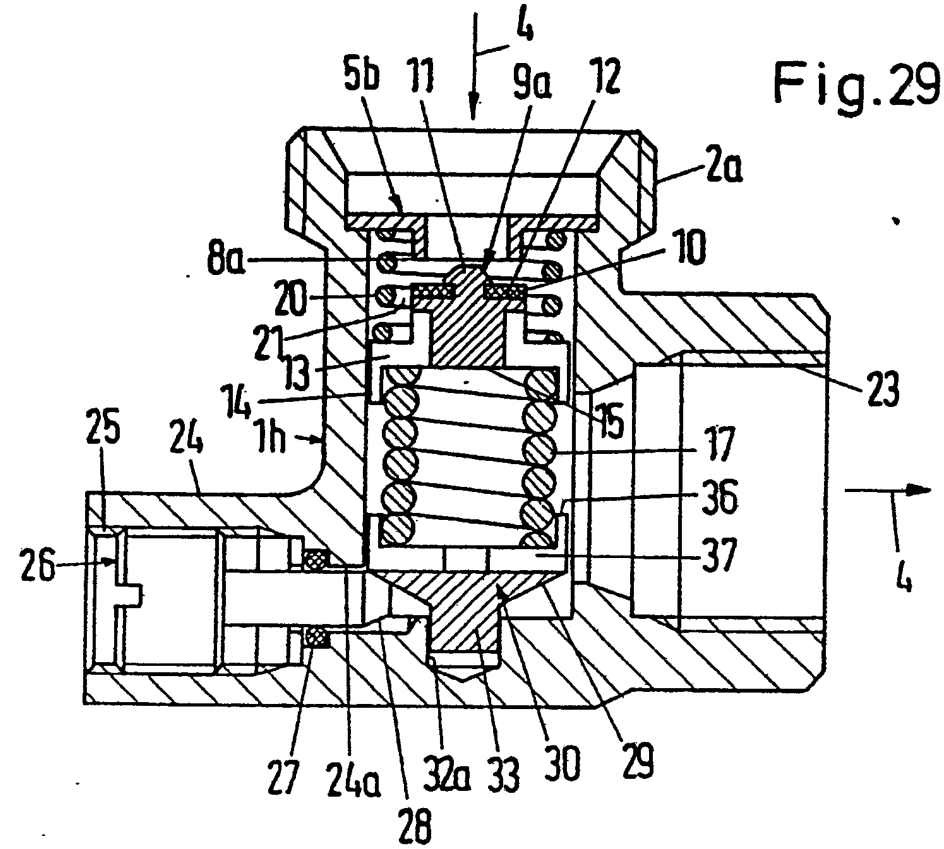
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Fig.29

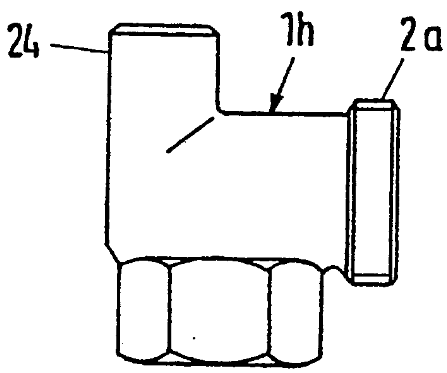
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Fig. 30

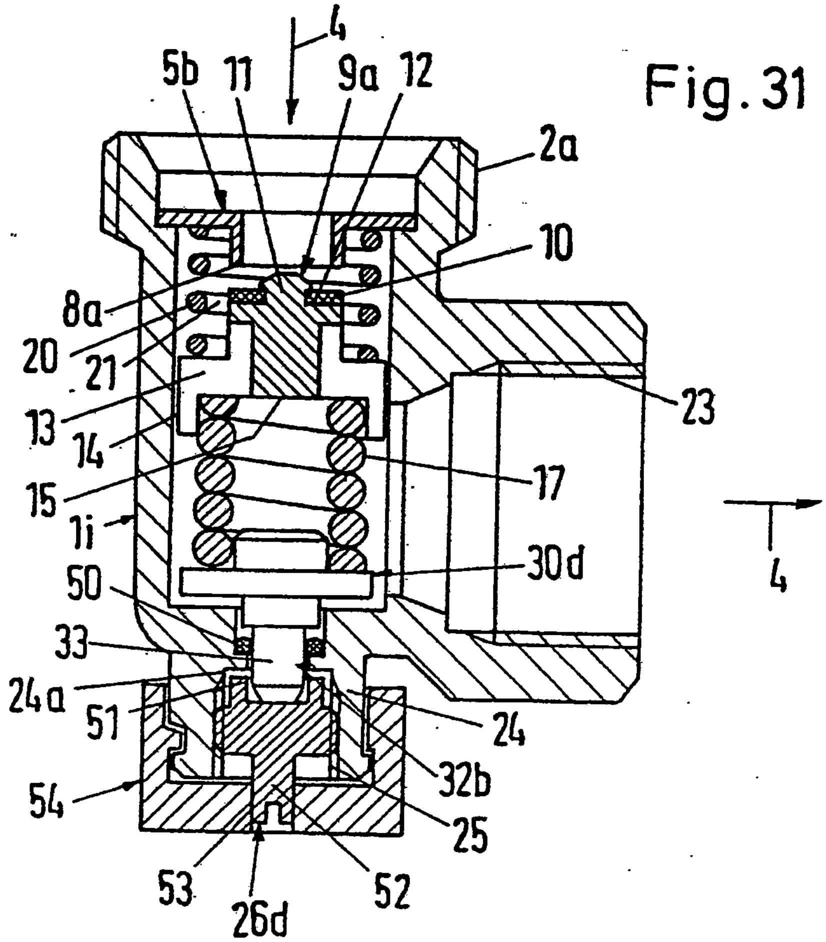
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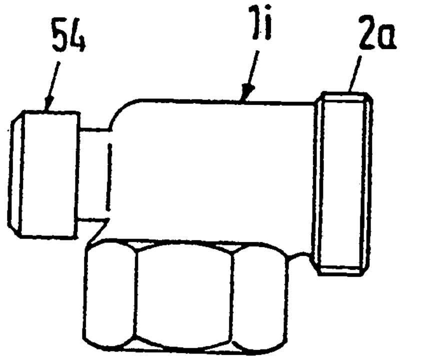
Fig. 31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1i
2a

Fig. 32

Fig. 34

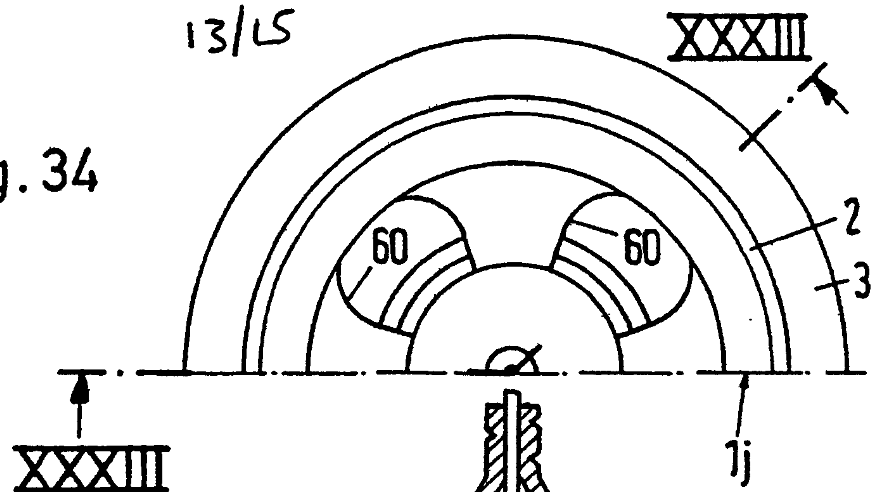

Fig. 33

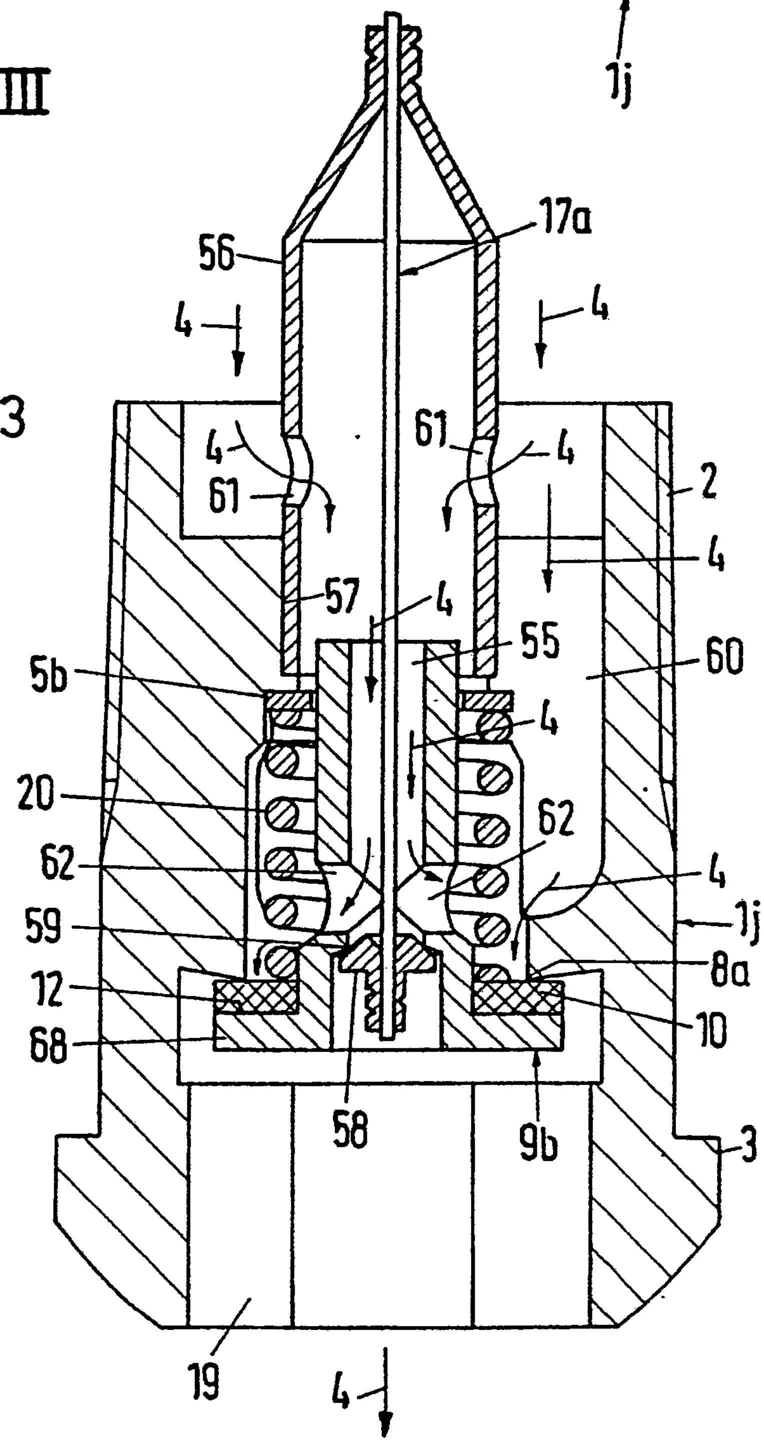

Fig. 35

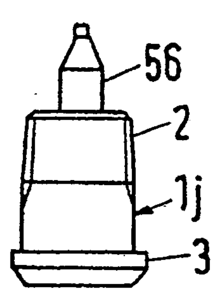

Fig. 36

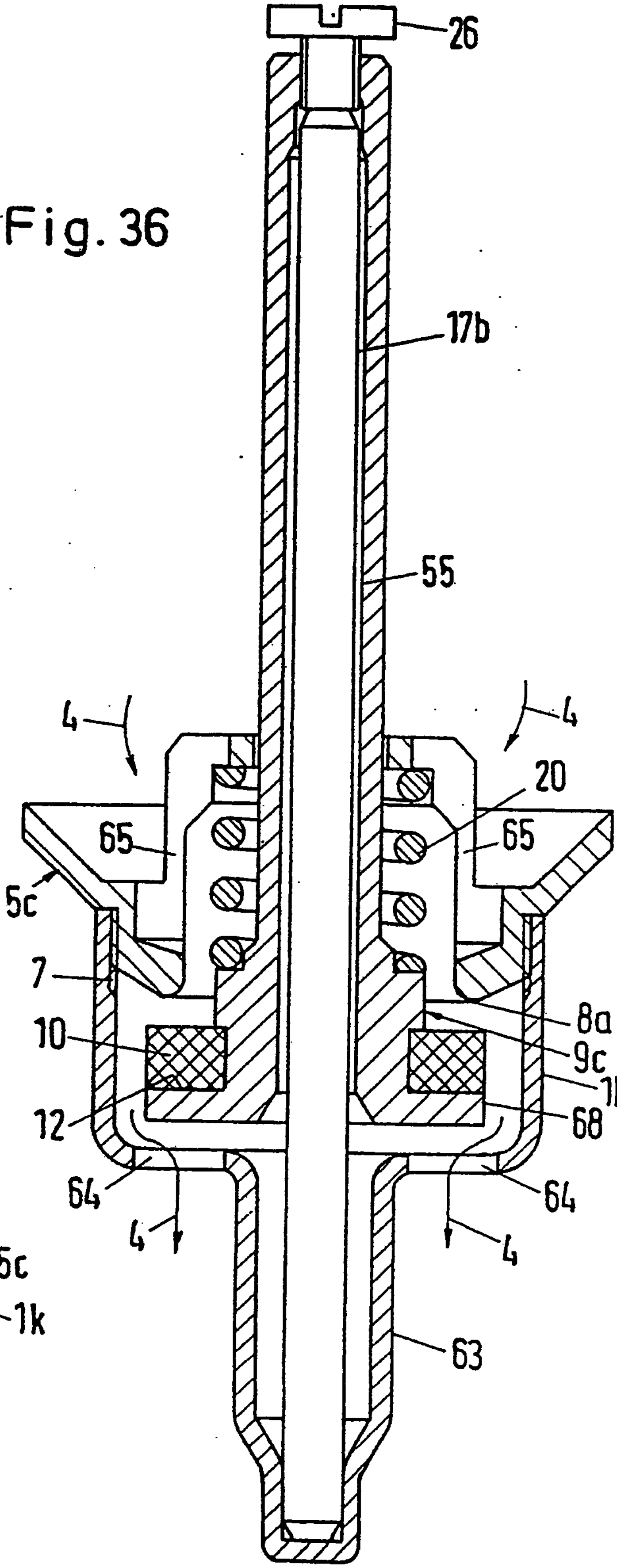

Fig. 37

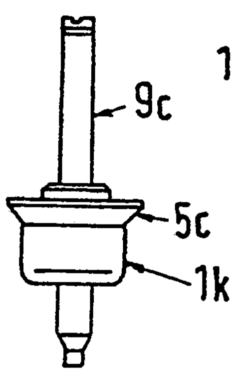

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Fig. 38

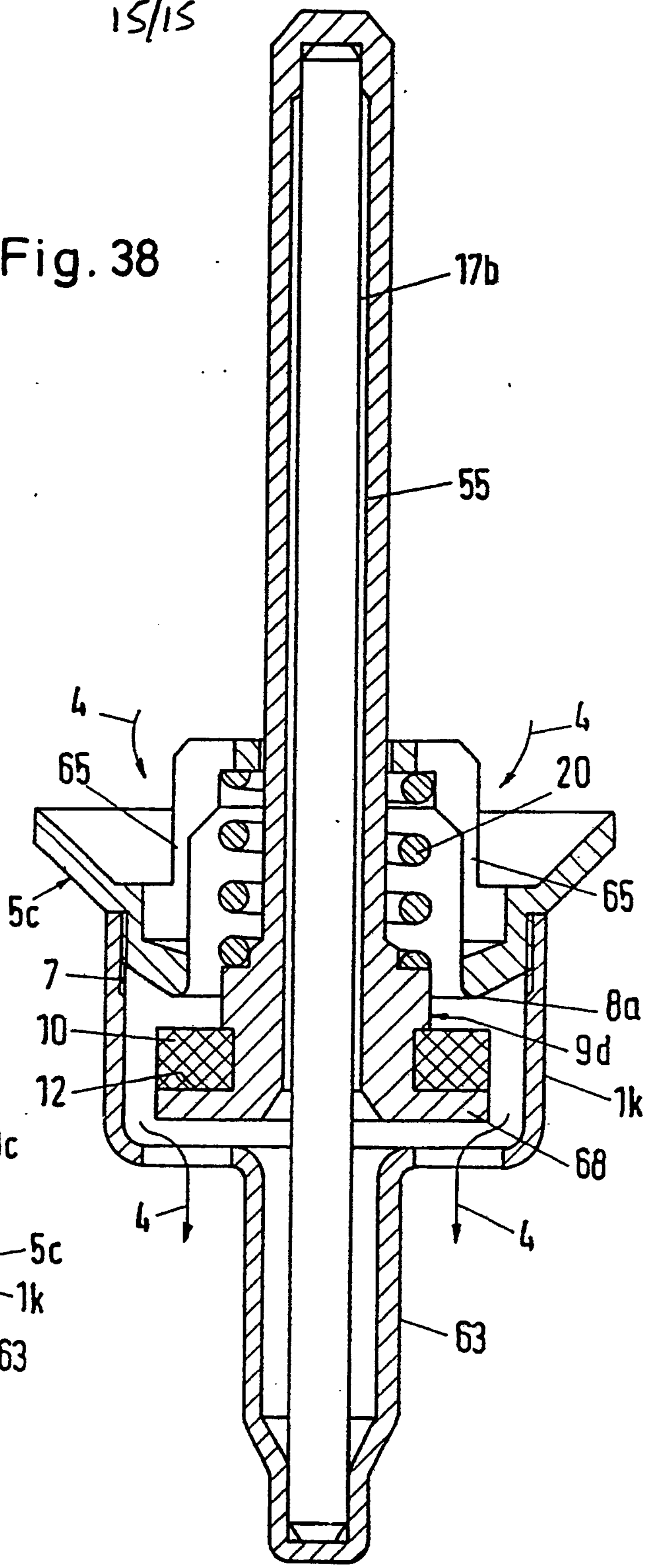
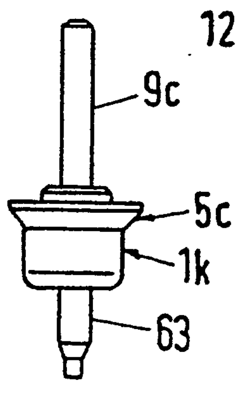


Fig. 39



Temperature-Responsive Valves

This invention relates to temperature-responsive valves.

A known type of temperature-responsive valve comprises a housing through which, in use, fluid passes and in which there are arranged, substantially co-axially with each other, a first helical spring which, in use, expands and contracts depending on the temperature of fluid passing through the valve, acts against the housing and is arranged to bring about the closing and opening of the valve, and a second, substantially temperature-insensitive, helical spring for biasing the first helical spring.

In a known valve of that type, the temperature-sensitive helical spring is made of metal having a shape memory, a so-called SME (shape memory effect) metal. One end of the spring lies against a collar, projecting radially inwardly, of a through-flow passage in the housing, and its other end lies against a plate having a central tapped hole in which a headed screw is screwed. One end of the second helical spring acts against the head of the screw by way of a second plate, which second plate is seated on the shank of the screw by having a central hole, whilst the other end of the second spring acts likewise against the collar in the through-flow passage. When a high temperature obtains, the fluid flows through the turns of the temperature-sensitive

helical spring. If, however, the temperature falls, the turns of the temperature-sensitive helical spring become closer to each other and thereby throttle the flow against the force of the second spring. As the temperature continues to drop, the turns finally lie against each other so that the flow is, as will be explained hereafter, completely blocked. Upon a rise in temperature, the temperature-sensitive helical spring expands against the force of the second spring so that the flow is started again. The two helical springs are co-axially seated within each other because the collar on the inside of the temperature-sensitive spring has a portion angled axially-inwards and then is angled radially again and the second helical spring acts against the radially-angled inner marginal section of the collar. To ensure a fluid-tight abutment when the turns of the temperature-sensitive helical spring lie against each other, the wire of the spring is provided with a resilient covering or with a radially-projecting sealing strip. In that construction, the temperature-sensitive helical spring has a large external diameter and were it not for the expensive-to-provide additional covering or sealing strip there would be an inadequate seal when the turns of the temperature-sensitive helical spring have contracted to lie against each other. If one were to reduce the diameter of the temperature-sensitive helical spring to enable the valve to be installed in a pipe having a

comparatively small internal diamet r, for exampl , into the return conduit of a radiator of a central heating installation, that would reduce to an excessive extent the cross-sectional area for free flow when the valve was open.

The invention is based on the problem of providing a valve of the afore-mentioned kind of which the external diameter can be kept comparatively small and which does not markedly influence the flow in the open condition when installed in the return pipe of a central heating installation to limit the temperature of the return flow.

According to the invention, that problem is solved by the provision of a temperature-responsive valve comprising a housing through which, in use, fluid passes and in which there are arranged, substantially co-axially with each other, a first helical spring which, in use, expands and contracts depending on the temperature of fluid passing through the valve, acts against the housing and is arranged to bring about the closing and opening of the valve, and a second, substantially temperature-insensitive, helical spring for biasing the first helical spring, wherein a valve seat and a valve closure member are provided within the housing, the temperature-responsive first helical spring has one end acting against the housing and the other end acting against that side of the valve closure member remote from the valve seat, the second helical spring has one end

acting against the housing at a location radially outwards of the valve closure member, and the other end acting against that side of the valve closure member facing the valve seat and acts against the force of the first helical spring tending to close the valve, and at least one aperture is provided in the valve closure member establishing communication between the interior of the first helical spring and an annular chamber, within the second helical spring, located radially outwards of the valve seat.

In such a construction, the fluid need not flow between the turns of the helical spring in the open condition of the valve. Instead, it can for the most part flow through the interior of the springs. The valve diameter can therefore be kept very small. Consequently, the valve can also be built into pipes of comparatively small diameter, and even installed as a subsequent modification, for example, into the return pipe of a central heating radiator for limiting the temperature of the return flow. In the afore-mentioned known valve, however, one must leave an annular space, corresponding to the maximum flow section, outside the temperature-responsive helical spring. Further, since the diameter of the temperature-sensitive helical spring in the case of the known valve cannot be markedly reduced in size if an adequate flow section is to be maintained between the turns of the spring in the case of a short spring and

because the second helical spring is disposed within the temperature-sensitive helical spring, the known valve has a comparatively large external diameter. In addition, in the known valve the second helical spring impedes the through-flow because as the temperature-sensitive spring expands, the second spring contracts and correspondingly reduces the free section for flow between the turns of the spring.

Preferably, the first helical spring is a shape memory effect spring.

In a development of the valve according to the invention, the valve closure member comprises a resilient sealing disk on that side of the valve closure member facing the valve seat. That arrangement ensures an efficient seal in the closed condition of the valve. Such a sealing disk is not only simple to apply but also leaves the surface of the temperature-responsive coil spring free so that the latter makes direct contact with the fluid and responds very rapidly to temperature fluctuations.

Preferably, the valve closure member is substantially cup-shaped and has apertures passing radially through the circumferential wall of the cup-shaped valve closure member. Such an arrangement gives a large free section for flow in the valve closure member radially beyond the valve seat, it being possible for the temperature-sensitive helical spring to be arranged on the outside or

inside of the wall of th cup and be positioned thereby.

Preferably, the apertures extend over substantially the entire axial length of the valve closure member and pass through a part, lying to the side of the valve seat, of a base of the valve closure member.

Further, the end of the first and/or second helical spring remote from the valve closure member can act against an axially-adjustable counter-bearing.
Such an arrangement permits the characteristic of the valve to be set, manufacturing tolerances to be compensated, and the set closing and opening point to be manually overridden because adjustment of the counter-bearing not only changes the bias of the closure member but also its spacing from the valve seat.

Preferably, the end of the first helical spring acts against an axially-adjustable counter-bearing, and an aperture is provided in the housing through which a setting tool may be inserted for the purpose of adjusting the counter-bearing of the first helical spring. In such a construction, the valve can easily be set from outside the valve housing without removing the valve from a pipe into which it has been installed.

If the end of the second helical spring acts against an axially-adjustable counter-bearing, and the valve seat forms part of the counter-bearing of the second helical spring, the counter-bearing will fulfil a dual function.

The above-mentioned problem can also be solved in accordance with the invention by a second solution. According to the second solution, the present invention provides a temperature-responsive valve comprising a housing through which, in use, fluid passes and in which there are arranged, substantially co-axially with each other, a metal actuating element which, in use, expands and contracts depending on the temperature of fluid passing through the valve, acts against the housing and is arranged to bring about the closing and opening of the valve, and a substantially temperature-insensitive, helical spring for biasing the actuating element, wherein a valve seat and a valve closure member are provided within the housing, the actuating element is a pin-like element of which one end acts against the housing and the other end biases the valve closure member in the valve-closed direction, the helical spring acts on the valve closure member oppositely to the actuating element, and the actuating element passes substantially axially through the helical spring. The pin can have a very much smaller diameter than a helical spring so that it will not tend to have any marked influence on the free section for fluid flow and it is possible to arrange that the single helical spring alone will be traversed by fluid. Although the pin must be comparatively long to provide a sufficient operating stroke, the overall structural length can nevertheless be comparatively short

because the pin passes through the helical spring.

Preferably, the actuating element is a shape memory effect element.

Instead, a third solution is possible in accordance with the invention. In accordance with the third solution, the present invention provides a temperature-responsive valve comprising a housing through which, in use, fluid passes and in which there are arranged, substantially co-axially with each other, a metal actuating element which, in use, expands and contracts depending on the temperature of fluid passing through the valve, and is arranged to bring about the closing and opening of the valve, and a substantially temperature-insensitive, helical spring for biasing the actuating element, wherein a valve seat and a valve closure member are provided within the housing, the actuating element is a wire element of which one end acts on the valve closure member in the valve-closed direction and the other end is fixed relative to the housing, and the helical spring acts on the valve closure member oppositely to the wire, and the wire passes substantially axially through the helical spring. The third solution provides essentially the same advantages as the second solution in accordance with the invention.

Preferably, the actuating element is a shape memory effect element.

The valve closure member may be mounted by a

universal mounting. Such an arrangement ensures that the valve closure member will always lie completely against the valve seat when the valve is closed.

If one ensures that the valve closure member is a hollow cylindrical member and passes through the valve seat, the valve closure member has a flange projecting radially outwards, a radially-extending part of the flange faces the valve seat, a resilient sealing disk is provided on the side of the flange facing the valve seat, and one end of the actuating element is received in the hollow space of the valve closure member, one can use a still longer pin or wire with a correspondingly longer actuating stroke per unit change in temperature.

The second solution, particularly but not exclusively, can be developed in that the valve closure member includes a stepped axial bore, and a connecting member, under the bias of the helical spring, contacts firmly, from the outlet side of the valve, an edge in the bore defining the step, one end of the actuating element passing through the bore and being secured to the connecting member. Such an arrangement provides a universal mounting for the valve member in a simple manner. With particular advantage, the actuating element in this construction may be of SME metal which contracts axially upon heating and expands upon cooling, the helical spring providing a tensile loading of the actuating element. The actuating element can therefore

be very thin, preferably a wire as in the third solution, because the danger of kinking as would tend to occur if the actuating element were loaded in compression is avoided. Accordingly, the diameter of the entire valve can be still further reduced.

Instead of the last-mentioned arrangement, it is also possible for the housing to be substantially cup-shaped, the base of the cup to have a hollow cylindrical extension receiving and axially supporting the other end of the actuating element, and axial-flow apertures to be provided in the base of the cup radially beyond the cylindrical extension. Such an arrangement readily accommodates an extended length for the actuating element with a corresponding increase in sensitivity.

In the second solution particularly, but not exclusively, the end of the helical spring remote from the end acting on the valve closure member may act against an axially-adjustable counter-bearing so that the same advantages are obtained as in the first solution.

The same applies if the counter-bearing of the helical spring includes the valve seat, especially in the case of the second solution.

The end of the actuating element received in the hollow cylindrical valve closure member may act against an axially-adjustable counter-bearing. In that way, one likewise obtains the possibility of adapting the charac-

teristic curve of the valve to a particular application.

Temperature-responsive valves constructed in accordance with the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is an enlarged axial section through a first valve in accordance with the invention;

Figure 2 is a side elevation of the valve of Figure 1 shown (on the original drawings filed with this application) substantially at its actual size;

Figure 3 is a plan view of a closure member shown in Figure 4;

Figure 4 is an enlarged side elevation of a closure member used in the valve of Figure 1;

Figure 5 is an axial section through the closure member taken on the line V-V marked in Figure 4;

Figure 6 is a side elevation of the closure member of Figure 4 shown (in the original drawings accompanying this application) substantially at its actual size;

Figure 7 is an axial section through a second valve according to the invention to an enlarged scale;

Figure 8 is a side elevation of the valve of Figure 7 substantially (in the original drawings accompanying this application) at its actual size;

Figure 9 is an enlarged axial section through a third valve according to the invention;

Figures 10 and 11 are respectively a side elevation

and a plan view of a counter-bearing in th valve of Figure 9;

Figures 12 and 13 are respectively a side elevation and a plan view of a closure member of the valve of Figure 9;

Figure 14 is a side elevation of the valve of Figure 9 shown (in the original drawings accompanying this application) at substantially its actual size;

Figure 15 is an axial section through a fourth valve according to the invention shown to an enlarged scale;

Figure 16 is a side elevation of the valve of Figure 15 shown (in the original drawings accompanying this application) at substantially its actual size;

Figure 17 is an enlarged axial section through a fifth valve embodying the invention;

Figure 18 is a side elevation of the valve of Figure 17 shown (in the original drawings accompanying this application) at substantially its actual size;

Figure 19 is an enlarged axial section through a sixth valve according to the invention;

Figure 20 is a side elevation of the valve of Figure 19 shown (in the original drawings accompanying this application) at substantially its actual size;

Figure 21 is an enlarged axial section through a seventh valve according to the invention;

Figure 22 is a cross-section through the valve of

Figure 21;

Figure 23 is a side elevation of the valve of Figure 21 shown (in the original drawings accompanying this application) at substantially its actual size;

Figure 24 is an enlarged axial section through an eighth valve in accordance with the invention;

Figure 25 is a side elevation of the valve of Figure 24 shown (in the original drawings accompanying this application) at substantially its actual size;

Figure 26 is an enlarged axial section through a ninth valve in accordance with the invention;

Figure 27 is a cross-section through an eccentric bolt of the valve of Figure 28;

Figure 28 is a side elevation of the valve of Figure 26 shown (in the original drawings accompanying this application) at substantially its actual size;

Figure 29 is an enlarged axial section through a tenth valve in accordance with the invention;

Figure 30 is a side elevation of the valve of Figure 29 shown (in the original drawings accompanying this application) at substantially its actual size;

Figure 31 is an enlarged axial section through an eleventh valve in accordance with the invention;

Figure 32 is a side elevation of the valve of Figure 31 shown (in the original drawings accompanying this application) at substantially its actual size;

Figure 33 is an axial section through a twelfth

valve in accordance with the invention to an enlarged scale;

Figure 34 shows half of a plan view of the valve of Figure 33;

Figure 35 is a side elevation of the valve of Figure 33 shown (in the original drawings accompanying this application) at substantially its actual size;

Figure 36 is an enlarged axial section through a thirteenth valve in accordance with the invention;

Figure 37 is a side elevation of the valve of Figure 36 shown (in the original drawings accompanying this application) at substantially its actual size;

Figure 38 is an enlarged axial section through a fourteenth valve in accordance with the invention; and

Figure 39 is a side elevation of the valve of Figure 39 shown (in the original drawings accompanying this application) at substantially its actual size.

Referring to the accompanying drawings, a first valve in accordance with the invention shown in Figures 1 and 2 comprises a hollow cylindrical housing 1 with a conical external screwthread 2 for screwing into a fitting in a return conduit of a radiator of a hot water heating installation, and an annular flange 3 behind which a cap nut of the fitting is brought to abut as the valve is being built into the return conduit.

The direction in which flow takes place through the valve is indicated by the arrows 4.

On the inlet side, a screw-threaded ring 5 with an external hexagon formation is screwed into an internal screwthread 7 of the housing 1. The axially-inner end face of the screw-threaded ring 5 forms a valve seat 8 for a closure member 9. On the side facing the valve seat 8, the closure member 9 has a resilient sealing disk 10, for example, of rubber, in the form of an annular disk which surrounds the neck of a generally mushroom-shaped projection 11 facing the valve seat 8. The disk 10 is supported on an annular shoulder 12 of the valve closure member 9. The valve closure member is substantially cup-shaped and is provided with apertures 13 which pass radially through the circumferential wall 14 of the valve closure member 9 over its entire axial length and through part of the base 15 of the valve closure member 9, which base lies on the same side as the valve seat 8. The circumferential wall 14 is further provided with a radially- outwardly projecting annular flange 16, against the side of which, remote from the valve seat 8, one end of a temperature-responsive helical spring 17 acts, the other end of the spring acting against an inner shoulder 18 of the housing 1, which shoulder forms the axially-inner end of an internal hexagon formation 19 at the outlet end of the housing 1. The helical spring 17 consists of a metal having the effect of memorizing its shape, also known as an SME metal where the letters SME stand for shape memory

effect. Th metal can be, for example, a copper alloy, for example, CuZnAl. That material has the property of expanding considerably on heating and contracting again on cooling.

One end of a second helical spring 20 acts on the other side of the annular shoulder 16, the other end of the second spring acting against the axially-inner end face of the screw-threaded ring 5 at a location radially beyond the valve seat 8. The internal diameter of the helical spring 20 is larger than the external diameter of the circumferential wall 14 of the valve closure member 9 so that an annular chamber 21 remains between the helical spring 20 and the valve closure member 9 for the passage of the hot water when the valve is open.

When the valve is built into the return conduit of a radiator, the turns of the temperature-sensitive helical spring 17 will lie closely juxtaposed, when the valve is open, for as long as the water temperature is below a lower limiting value at which the force of the helical spring 17 is less than that of the helical spring 20. Upon a rise in temperature, the force of spring 17 increases until it finally exceeds the force of spring 20 and presses the valve closure member 9 against the valve seat 8. In the now closed position of the valve, the water in the radiator and in the return conduit can cool off because the supply of more hot water is blocked. In this closed position, the turns of the spring 17 lie

apart so that the water makes contact over a large area with the spring 17.

After the water has cooled off sufficiently, the helical spring 17 will contract axially again so that the valve closure member 9 is lifted off the valve seat 8 under the force of the spring 20 and the flow is freed again until the water temperature in the housing 1 again falls below the lower limiting value.

By reason of using the shape memory effect metal for the helical spring 17, even a slight change in the temperature of, for example, 5 to 10 degrees C will enable the entire stroke of the valve closure member 9 to be executed so that the valve will be very sensitive in responding to temperature changes. The high speed of response results from the low mass of the helical spring 17 and the corresponding low thermal capacity. Furthermore, the large surface area of spring 17 contributes to a reduction in the time taken for the valve to respond to temperature change.

The use of SME metal for the spring 17 has the additional advantage that the length/temperature characteristic of the spring 17 is independent of the static pressure of the water, in contrast with an actuating element having a temperature-responsive expansible material such as a vapour, a liquid or wax in an expansible container.

The screw-threaded ring 5 serves as an adjustable

counter-bearing for the helical spring 20. By adjusting the ring 5, it is therefore possible not only to select the pre-stressing of the helical spring 20 but also the spacing between the sealing disk 10 and the valve seat 8 in the open condition of the valve so that on the one hand the hysteresis of the valve is reduced and on the other hand it is possible to set different opening and closing temperatures.

In the open condition of the valve, the water flows practically unhindered through the screw-threaded ring 5, the annular chamber 21 and in part also through the annular chamber located outside the spring 20, through the apertures 13, the interior chamber of the valve closure member 9, and the interior of the helical spring 17 without any marked hindering of the through-flow. The internal diameter of the housing 1 can therefore be approximately the same as the external diameter of the helical springs 17 and 20. It is necessary only to maintain a certain amount of clearance between the external circumference of the helical springs 17 and 20 and the inside of the housing 1 in order to permit movement of springs 17 and 20 and of the valve closure member 9 within the housing 1. With a comparatively large flow section, the valve can therefore nevertheless have a small external diameter so that it can even be built into existing return conduits and conventional fittings having a small internal diameter.

In the return conduit, the valve serves as an automatic return temperature-limiting device. In that way, one can obtain a low temperature for the returned water. That leads to a higher efficiency in boilers which employ heat exchange with the flue gases. Upon starting-up the heating installation, losses are avoided if there has been a preceding reduction in the desired temperature setting, for example, during night time. Losses are also avoided if the desired value of the temperature upstream of the valve is increased. Furthermore, losses which would arise as a result of ventilating a heated room without reducing the temperature upstream of the valve are avoided.

The use of the resiliently yielding sealing disk 10 ensures that the valve will seal tightly without the subjection of the helical spring 17 to high excess temperatures and a correspondingly high closing force which could result in the valve displaying greater hysteresis.

The embodiment of Figures 7 and 8 differs from that of Figures 1 to 6 essentially only in that the housing 1a has thinner walls, does not have a screwthread and is provided at the inlet with a part-conical flange 22, and the valve seat 8 is in the form of an annular disk forming part of a counter-bearing 5a which is fixed with respect to the housing. The shoulder 18 of housing 1a, serving as a counter-bearing for the helical spring 17,

is able to be deformed by being pushed axially-inwards by means of a suitable setting tool in order to set the free distance between the counter-bearings 5a and 18 for the helical springs 17 and 20 and thus their pre-stressing so that the opening and closing temperatures of the valve can be set to the desired values. This valve again has a small external diameter, as can be seen from Figure 8, so that it can easily be inserted in a conventional return conduit and secured with a cap nut.

In the embodiment of Figures 9 to 14, the housing 1b is provided on the inlet side with a cylindrical external screwthread 2a and on the outlet side with an internal screwthread 23 and an external hexagon formation to enable it to be connected into the return conduit. Furthermore, the valve has a nipple 24 projecting radially which is connected to an aperture in the housing 1b and has an internal screwthread 25 into which there is screwed a set screw 26 which is sealed within the nipple 24 by means of an O-ring 27 and has a conical tip 28. The conical tip 28 of the set screw 26 bears against a complementary conical external surface 29 of a counter-bearing 30 for the temperature-sensitive helical spring 17, the surface 29 being on the side of the counter-bearing 30 remote from the spring 17. Furthermore, the housing 1b contains a substantially "star-shaped" guide member 31 having a hub 32 coaxial with the axis of the housing 1b. The counter-bearing 30 is

mounted, so as to be axially-displacable, in the hub 32 by a cylindrical extension 33 on the side of the counter-bearing 30 remote from the helical spring 17. Radially-extending webs 34 of the guide 31 reaching to the wall of the housing define between each other axial apertures for the through-flow of water. The side of the counter-bearing 30 facing the helical spring 17 is substantially cup-shaped and has in its circumferential wall 36 radially and axially-extending apertures 37 which also extend partially through the base 38 of the counter-bearing 30. One end of the temperature-responsive helical spring 17 acts against the base 38 of the counter-bearing 30. The other end of the spring 17 acts against the base 15 of the closure member 9a which is of the same construction as the valve closure member 9 of the first embodiment except that the flange 16 has been omitted and, instead, the internal diameter of the still substantially cup-shaped valve closure member 9a is increased so that the helical spring 17 is received within the circumferential wall 14. The valve seat 8a is in the form of a rim.

In this embodiment, the water can flow through not only the interior of the temperature-responsive helical spring 17 but also outside the spring when the valve is open. Even with the valve closed, practically the entire surface of the temperature-responsive helical spring 17 is in contact with the water so that the response delay

or tim constant of spring 17 with respect to a change in temperature is further reduced. Nevertheless, the valve has a comparatively small external diameter and yet a sufficiently free section for flow. The counter-bearing 30 can be adjusted by means of the set screw 26 and thus an adjustment additional to that achievable to that provided by the screw-threaded ring 5 is possible, the adjustment of the set screw 26 being possible from the outside even when the valve is built into the return conduit. Furthermore, the set screw 26 can, if desired, be screwed in so deeply that the valve is tightly closed and the thermostatic function is overridden.

The construction of the valve seat 8a in the form of a rim gives a greater surface pressure and thus a better sealing effect for a given contact force by the valve closure member 9a compared with the preceding embodiments.

Insofar as the embodiment of Figures 15 and 16 uses the same components as the preceding embodiments, the same reference numerals are used. The main difference is that the valve has an angled housing 1c and in addition to the screw-threaded ring 5, a securing ring 39 is provided in the housing 1c. Furthermore, the apertures 13a do not extend over the entire length of the circumferential wall 14 of the valve closure member 9.

The embodiment of Figures 17 and 18 differs from that of Figures 15 and 16 only in that the screw-threaded

ring 5 has a valve seat 8 identical with that of the Figure 1 embodiment and the securing ring 39 is omitted.

The embodiment of Figures 19 and 20 likewise has an angled housing 1d. Whereas the counter-bearing 5b for the helical spring 20 is fixed with respect to the housing, the counter-bearing 30a for the helical spring is again in this case adjustable. For that purpose, the counter-bearing 30a has an external screwthread 40 by which it engages with an internal screwthread 41 in a substantially cup-shaped cylindrical extension 42 of housing 1d, the extension being in alignment axially with the helical springs. The counter-bearing 30a is sealed against the housing extension 42 by means of two O-rings 43. Between the O-rings 43, the counter-bearing 30a has an outwardly facing row of recesses 44, the walls between the recesses defining a toothed ring. The recesses 44 are accessible to a setting tool (not shown), for example, a screwdriver, by way of an elongate aperture 24b of housing 1d. In that way the counter-bearing 30a can be turned to thereby make an adjustment of its axial position.

The embodiment of Figures 21 to 23 corresponds substantially to that of Figures 19 and 20 except that here the housing 1e is provided with the nipple 24 and as a setting element a worm gear 26a is provided, the helix 45 of the worm gear engaging in the gaps 44a between the teeth of a gear ring surrounding the counter-bearing 30b.

The worm gear 26a is provided with a collar 46 abutting a bushing 47, which bushing is screwed into the thread 25 of nipple 24 and has an external screwthread for enabling the worm gear 26a to be retained in position.

On turning the worm gear 26a, the counter-bearing 30b is also turned and adjusted in its axial direction by reason of its screwthread 40 engaging in the screwthread 41.

The embodiment of Figures 24 and 25 again comprises an angled housing 1f and, as far as the inlet side is concerned, corresponds substantially to the embodiment of Figure 19 and, as far as adjustment of the counter-bearing 30 is concerned, corresponds substantially to the embodiment of Figures 9 to 14 except that the nipple 24 extends obliquely to the circumferential wall of the housing 1f and perpendicularly to the part-conical surface 29 of the counter-bearing 30. The setscrew 26b does not have a conical tip but has a flat surface at its end to contact the exterior surface 29 of the counter-bearing 30. The counter-bearing 30 is displaceably mounted in a guide bore 32a by means of a projecting portion 33. In this embodiment, the counter-bearing 30 of the spring 17 is again adjustable in the axial direction of spring 17 by turning the setscrew 26b.

The embodiment of Figures 26 to 28 corresponds substantially to that of Figures 24 and 25 except that

the setting element 26c has an ecc ntric member 48 of which the cross-section is illustrated in Figure 28 and which contacts the side of the counter-bearing 30c remote from the valve closure member 9a, the counter-bearing being displaceable in the housing 1g. The setting element 26c is at one side rotatably mounted in the bushing 47 and at the other side rotatably mounted by an axial extension pin 49 in a bore of the housing 1g. By turning the setting element 26c, the counter-bearing 30c is likewise adjusted in the present embodiment.

The embodiment of Figures 29 and 30 corresponds substantially to that of Figures 24 and 25 except that the nipple 24 is again perpendicular to the inlet section of the housing 1h and the setscrew 26 is provided with a conical tip as in the embodiment of Figure 9. The operation is therefore the same as in the embodiment of Figure 19.

In the embodiment of Figures 31 and 32, which likewise includes an angled housing 1i, the inlet portion likewise corresponds to that of the valve of Figure 19. On the other hand, the cylindrical axial projection 33 of the counter-bearing 30d is sealingly guided with the help of an O-ring 50 in a guide bore 32b which is co-axial with respect to the helical springs 17 and 20, the projection 33 engaging in an end recess 51 of the setscrew 26d in the housing extension and in the nipple 24, and the housing extension 24 being co-axial with

respect to the helical springs 17 and 20. Furthermore, by means of a shank portion 52 of reduced diameter relative to the threaded section the setscrew 26d passes through a co-axial bore 53 in a cap nut 54, which cap nut is screwed onto the nipple 24 and serves to secure the setscrew 26d axially. In this embodiment, adjustment of the counter-bearing 30d, and the helical springs 17 and 20, in the housing 1i co-axial with the inlet section is brought about by turning the setscrew 26d.

In the embodiment of Figures 33 to 35, the temperature-responsive actuating element 17a is a thin cylindrical wire. The material of the wire 17a is preferably an SME metal of nickel-titanium alloy prepared so that the wire 17a contracts on heating and expands on cooling. That alloy can, however, also be made so that it expands on heating and contracts on cooling. Compared with Cu-Zn-Al alloy, it has the advantage of a greater change in length with respect to temperature. A very thin wire will therefore be sufficient to operate the valve. The wire 17a has one end received in an axial through-going bore 55 of the valve closure member 9b and its other end secured to a sleeve 56, which sleeve is co-axial with the housing 1j, projects axially from the housing 1j, and is secured by its inner end in a co-axial bore 57 of the housing 1j so that the sleeve 56 forms a counter-bearing fixed with respect to the housing for the wire 17a clamped therein.

The counter-bearing 5b for the helical spring 20 at the same serves to centre the valve closure member 9b whilst allowing the valve closure member some radial play during axial displacement of the valve closure member.

The end of the wire 17a received in the bore 55 of the closure member 9b is tightly clamped in a connecting or movable-joint-defining member 58 with a conical sealing face. The connecting member 58 is held, from the outlet side of the valve, sealed against an edge 59 of a step in the bore by means of the force of the temperature-insensitive helical spring 20, which acts by way of a sealing disk 10 on the annular shoulder 21 of a radially outwardly-projecting flange 68 of the valve closure member 9b, while the valve closure member 9b is lifted off the valve seat 8a. With the valve members 8a and 9b in the closed position, the connecting member 58 lies against the edge 59 under the tensile force applied by the wire 17a which contracts on heating and expands on cooling, so that the connecting member 58 lies tightly against the edge 59 under all operating conditions and prevents the passage of fluid but at the same time provides a kind of universal mounting for the valve closure member 9b. The universal mounting or bearing ensures that the valve closure member 9b does not take up an oblique position relative to the valve seat 8a but will always lie against the entire valve seat 8a in the closed condition of the valve.

Th housing 1j is provided with axial passages 60 which open radially inwards into the bore 57 and provide a passage for the hot water externally of the helical spring 20. The helical spring 20 is positioned inwardly of the valve seat 8a on the sealing disk 10 and is radially spaced from the operative part of the seat.

When the valve components 8a and 9b are in the open condition, the hot water can flow on the one hand through radial bores 61 in the sleeve 56, the bore 55, radial bores 62 of the valve closure member 9b and the intermediate spaces between the turns of the helical spring 20 and on the other hand through the passages 60.

When the wire 17a cools down and expands, the valve components 8a and 9b open under the force of spring 20.

The helical spring 20 has dimensions such that its turns will, even with the valve components 8a and 9b in the closed condition, exhibit sufficient spacing for hot water to pass through the turns of the spring.

In this embodiment again, hot water can flow through the housing 1j practically unhindered when the valve components 8a and 9b are in the open condition, it again being possible to have a very small external diameter for the housing 1j because the temperature-sensitive actuating element 17a likewise has a very small diameter and, by reason of its considerable length, nevertheless provides a long actuating stroke for a small temperature change.

In the embodiment of Figures 36 and 37, the actuating element 17b is an elongate pin of SME metal which expands on heating and contracts on cooling and which is considerably longer than the housing 1k of the valve. Here, again, the valve closure member 9c is of hollow cylindrical form, passes through the valve seat 8a and projects from the housing 1k to a substantial extent. The temperature-sensitive pin 17b projects with one end into the bore 55 of the valve closure member 9c and with its other end into a hollow cylindrical base extension 63 of the otherwise substantially cup-shaped housing 1k of which the base is provided with axial apertures 64 positioned radially further out than the extension 63.

The counter-bearing 5c for the temperature-insensitive helical spring 20 is in the form of a cap nut which is screwed into the internal screwthread 7 of the housing 1k and is provided with lateral apertures 65 for the passage of the hot water.

The pin 17b is mounted at one end at the base of the extension 63 and at the other end at the setscrew 26 which is screwed into that end of the valve closure member 9c that projects from the housing 1k, the setscrew abutting the end of the pin 17b. In this embodiment, the valve stroke and pre-stressing of the helical spring 20 are likewise adjustable by turning the setscrew 26 and, if desired, by turning the counter-bearing 5c.

The embodiment of Figures 38 and 39 differs from

that of Figures 36 and 37 only in that the setscrew 26 is omitted and the valve closure member 9d is instead closed at the end projecting from the housing 9k.

CLAIMS:

1. A temperature-responsive valve comprising a housing through which, in use, fluid passes and in which there are arranged, substantially co-axially with each other, a first helical spring which, in use, expands and contracts depending on the temperature of fluid passing through the valve, acts against the housing and is arranged to bring about the closing and opening of the valve, and a second, substantially temperature-insensitive, helical spring for biasing the first helical spring, wherein a valve seat and a valve closure member are provided within the housing, the temperature-responsive first helical spring has one end acting against the housing and the other end acting against that side of the valve closure member remote from the valve seat, the second helical spring has one end acting against the housing at a location radially outwards of the valve closure member, and the other end acting against that side of the valve closure member facing the valve seat and acts against the force of the first helical spring tending to close the valve, and at least one aperture is provided in the valve closure member establishing communication between the interior of the first helical spring and an annular chamber, within the second helical spring, located radially outwards of the valve seat.

2. A valve as claimed in claim 1, wherein the first helical spring is a shape memory effect spring.

3. A valve as claimed in claim 1 or claim 2, wherein the valve closure member comprises a resilient sealing disk on that side of the valve closure member facing the valve seat.

4. A valve as claimed in any one of claims 1 to 3, wherein the valve closure member is substantially cup-shaped and has apertures passing radially through the circumferential wall of the cup-shaped valve closure member.

5. A valve as claimed in claim 4, wherein the apertures extend over substantially the entire axial length of the valve closure member and pass through a part, lying to the side of the valve seat, of a base of the valve closure member.

6. A valve as claimed in any preceding claim, wherein the end of the first and/or second helical spring remote from the valve closure member acts against an axially-adjustable counter-bearing.

7. A valve as claimed in claim 6, wherein the end of the first helical spring acts against an axially-adjustable counter-bearing, and an aperture is provided in the housing through which a setting tool may be inserted for the purpose of adjusting the counter-bearing of the first helical spring.

8. A valve as claimed in claim 6 or claim 7, wherein the end of the second helical spring acts against an axially-adjustable counter-bearing, and the valve seat

forms part of the counter-bearing of the second helical spring.

9. A temperature-responsive valve comprising a housing through which, in use, fluid passes and in which there are arranged, substantially co-axially with each other, a metal actuating element which, in use, expands and contracts depending on the temperature of fluid passing through the valve, acts against the housing and is arranged to bring about the closing and opening of the valve, and a substantially temperature-insensitive, helical spring for biasing the actuating element, wherein a valve seat and a valve closure member are provided within the housing, the actuating element is a pin-like element of which one end acts against the housing and the other end biases the valve closure member in the valve-closed direction, the helical spring acts on the valve closure member oppositely to the actuating element, and the actuating element passes substantially axially through the helical spring.

10. A valve as claimed in claim 9, wherein the actuating element is a shape memory effect element.

11. A temperature-responsive valve comprising a housing through which, in use, fluid passes and in which there are arranged, substantially co-axially with each other, a metal actuating element which, in use, expands and contracts depending on the temperature of fluid passing through the valve, and is arranged to bring about

the closing and opening of the valve, and a substantially temperature-insensitive, helical spring for biasing the actuating element, wherein a valve seat and a valve closure member are provided within the housing, the actuating element is a wire element of which one end acts on the valve closure member in the valve-closed direction and the other end is fixed relative to the housing, and the helical spring acts on the valve closure member oppositely to the wire, and the wire passes substantially axially through the helical spring.

12. A valve as claimed in claim 11, wherein the actuating element is a shape memory effect element.

13. A valve as claimed in any one of claims 9 to 12, wherein the valve closure member is mounted by a universal mounting.

14. A valve as claimed in any one of claims 9 to 13, wherein the valve closure member is a hollow cylindrical member and passes through the valve seat, the valve closure member has a flange projecting radially outwards, a radially-extending part of the flange faces the valve seat, a resilient sealing disk is provided on the side of the flange facing the valve seat, and one end of the actuating element is received in the hollow space of the valve closure member.

15. A valve as claimed in claim 14, wherein the valve closure member includes a stepped axial bore, and a connecting member, under the bias of the helical spring,

contacts firmly, from the outlet side of the valve, an edge in the bore defining the step, one end of the actuating element passing through the bore and being secured to the connecting member.

16. A valve as claimed in claim 14, wherein the housing is substantially cup-shaped, the base of the cup has a hollow cylindrical extension receiving and axially supporting the other end of the actuating element, and axial-flow apertures are provided in the base of the cup radially beyond the cylindrical extension.

17. A valve as claimed in claim 14 or claim 16, wherein the end of the helical spring remote from the end acting on the valve closure member acts against an axially-adjustable counter-bearing.

18. A valve as claimed in claim 17, wherein the valve seat forms a part of the counter-bearing.

19. A valve as claimed in any one of claims 15 to 18, wherein the end of the actuating element received in the hollow cylindrical valve closure member acts against an axially-adjustable counter-bearing.

20. A temperature-responsive valve substantially as herein described with reference to, and as illustrated by, Figures 1 to 6 of the accompanying drawings.

21. A temperature-responsive valve substantially as herein described with reference to, and as illustrated by, Figures 7 and 8 of the accompanying drawings.

22. A temperature-responsive valve substantially

as her in described with reference to, and as illustrated by, Figures 9 to 14 of th accompanying drawings.

23. A temperature-responsive valve substantially as herein described with reference to, and as illustrated by, Figures 15 and 16 of the accompanying drawings.

24. A temperature-responsive valve substantially as herein described with reference to, and as illustrated by, Figures 17 and 18 of the accompanying drawings.

25. A temperature-responsive valve substantially as herein described with reference to, and as illustrated by, Figures 19 and 20 of the accompanying drawings.

26. A temperature-responsive valve substantially as herein described with reference to, and as illustrated by, Figures 21 to 23 of the accompanying drawings.

27. A temperature-responsive valve substantially as herein described with reference to, and as illustrated by, Figures 24 and 25 of the accompanying drawings.

28. A temperature-responsive valve substantially as herein described with reference to, and as illustrated by, Figures 26 to 28 of the accompanying drawings.

29. A temperature-responsive valve substantially as herein described with reference to, and as illustrated by, Figures 29 and 30 of the accompanying drawings.

30. A temperature-responsive valve substantially as herein described with reference to, and as illustrated by, Figures 31 and 32 of the accompanying drawings.

31. A temperature-responsive valve substantially

as herein described with reference to, and as illustrated by, Figures 33 to 35 of the accompanying drawings.

32. A temperature-responsive valve substantially as herein described with reference to, and as illustrated by, Figures 36 and 37 of the accompanying drawings.

33. A temperature-responsive valve substantially as herein described with reference to, and as illustrated by, Figures 38 and 39 of the accompanying drawings.

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